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ABSTRACT

The focus of this research is to determine how soon and to what extent infant abilities are influenced by listening experience. Fourteen English-learning infants and fourteen Spanish-learning 6-8 month old infants participated in a first experiment; eight additional English and Spanish-learning infants participated in a second experiment. Infants in Experiment I received a training stimulus pair followed by three randomly assigned natural language contrasts from English, Spanish, and Czech. Infants in Experiment II received three vowel contrast and two nasal contrasts. In this second experiment, infants had to attend selectively to differences in the acoustic signal which pertained to phonemic distinctions and ignored irrelevant features of the signal. Results of Experiment I indicated that Spanish-learning infants significantly discriminated the Spanish, English, and Czech stimuli; the English-learning infants showed discrimination of the English and Czech stimuli, but not the Spanish. Results of Experiment II indicated that all vowel contrasts were highly discriminable by both infant groups, and significant differences were observed in difficulty among the vowel contrasts. The discussion of the research to date centers on tentative suggestions about the role of experience and additional factors in speech-sound discriminability. (AMH)

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Cross-linguistic Studies of Infant Speech Perception: The Role of Linguistic Experience

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Introduction

Previous research on childhood speech perception in meaningful setting has shown that many real speech contrasts present difficulties for young children of 18-36 months. Shvachkin (1973), Garnica (1971), Edwards (1974), Locke (1971), and Eilers and Oller (1976) have all reported systematic deficiencies in child performance in real speech two-choice discrimination tasks. In some cases the child performance is surprisingly poor, especially if one compares it with performance of 1-9 month old infants on similar speech or speech-like contrasts. An explanation for the apparent decrement in performance with age may be found in the fact that the real speech tasks used with older children require recognition of meaning as well as speech discrimination, while tasks used with infants require only discrimination. Thus, differences in task demands rather than differences in skill level may account for the apparent better performance of infants.

Even if infants do have high level auditory processing skills from the beginning of life, there may be substantial development as a result of linguistic listening experience and/or maturation across the first years of life. For most of a decade we have been involved in studies of infant and child speech perception. The infant studies we are involved in are directed in part toward illuminating the relationship of early speech processing skills and later developments as seen in the real speech studies with older children. The interest in possible development changes in speech perception skills has led us toward studies seeking possible effects of linguistic listening experience on infant perception.

Our focus in these infant studies has been quite distinct from that of a number of researchers who have focused on infant categorical discrimination and

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have emphasized innate capacities. Our work has been directed toward development of a general model of infant skills, a model in which linguistic experience as well as innate abilities are seen as important in determining discriminability of speech sounds. The question for us is not whether or not experience affects speech perception, but rather how soon and to what extent are infant abilities influenced by listening experience. The approach has involved some substantially different testing techniques, stimulus types and subject populations from those of most infant speech researchers since it is our goal to compare relative discriminability of various real speech contrasts in infants having different histories of linguistic listening experience.

Comparisons of relative discriminability of various contrasts are seen as central in our work as in the comparison of one language group to another language group. In this context, whether or not a particular contrast is discriminable in itself is of only secondary importance.

In the only thus far published study of speech discrimination in two groups of infants differing in language background and having been tested within a single laboratory setting, Eilers, Gavin and Wilson (1979) found that a group of Miami English-learning, 6-9 months old infants, were significantly less able to discriminate a synthetic Spanish voicing contrast ([ba] - [pa]) than a comparable group of Spanish-learning infants. The apparently better performance of the Spanish children on the Spanish contrast is of course presumed to reflect their experience, across the first months of life, with listening to spoken Spanish. In the Eilers, Gavin, and Wilson study, both groups of infants performed at a high level on a synthetic English voicing contrast ([pa] - [p^ha]). The success of both groups was interpreted as indicating that the English-like pair was psychoacoustically salient and thus its discriminability did not depend on linguistic experience.

Thus far possible effects of linguistic experience have been investigated only with a very limited stimulus inventory (synthetic labial stops differing in voice onset time) in published work. The ultimate understanding of effects of experience will depend upon studies with a wide variety of stimulus types both synthetically and naturally produced. It is toward the goal of adding to the stock of available cross-linguistic comparisons of infant perception that the present effort is directed.

For Experiment II infants were presented with multiple tokens of each stimulus category, all tokens produced by the same bilingual speaker. In Experiment II infants had to selectively attend to differences in the acoustic signal which pertained to phonemic distinctions and ignore irrelevant features of the signal associated with differences in amplitude, fundamental frequency, and duration.

All infants were tested using the VRISD (Visually Reinforced Infant Speech Discrimination) paradigm developed by Eilers, Wilson and Moore (1976). Infants were seated on a parent's lap in a sound insulated booth (see slide 1) facing toward E_1 who was entertaining the infant with quiet toys. A speaker and visual reinforcer were placed to the infant's side. The reinforcer was an animated toy housed in a dark plexiglass box. The toy was only visible when lighted during correct experimental trials. Both E_1 and the parent were presented with masking music through headphones and were thus blind to trial type.

At the start of the session, E_2, in the control room, iniates the background repeating syllable e.g., bit...bit...bit... When the infant is attending to E_1's toys, the background stimulus is changed to the contrastive member of the pair e.g., bIt...bIt...bIt... for six seconds. If the infant turns toward the speaker during this period, E_2 pushes a button on the computer terminal and the infant is rewarded by the presentation of the reinforcer for 3 seconds. After an initial training period in which amplitude as well as phonemic cues are used to teach the infant the headturn response, formal tesing begins. During formal testing the infant is presented with a fixed number of trials, approximately half of which are experimental trials and half of which are no-change trials or control trials, 40 trials for Experiment I and 30 trials for Experiment II. Trials are assigned in pseudo-random order by our DEC LAB 11/03 computer. E_2 is also blind to trial type throughout the study and merely initiates trials when the infant is in a ready state and indicates presence or absence of headturns during

the trial period. The administration of reinforcement and the tabulation and analysis of data is accomplished under computer control.

After testing, a discriminative index score is tabulated. This score is the number of hits (turns during experimental trials) minus the number of false positives (turns during control intervals) divided by the total number of possible hits. A score of 1.00, then, would mean perfect performance, no turns to control intervals and turns to every experimental trial. A score of 0 would indicate either no turns or equal numbers of turns to experimental and control trials. Negative scores would indicate more turns during controls than during experimentals. These DI scores are then statistically compared via Z tests to a model of non-discriminatory behavior. The Z's tell us whether or not a contrast is discriminable. More importantly, DI scores are entered into analysis of variance designs to determine differences between contrasts and language learning groups.

RESULTS

Results of Experiment I indicated that Spanish-learning infants significantly discriminated the Spanish, English and Czech stimuli. The English-learning infants provided evidence of discrimination of the English and Czech stimuli; but not the Spanish tap-trill distinction. More importantly, Spanish-learning infants showed significantly better discrimination of both the Spanish and Czech contrasts than English-learning infants.

Results of Experiment II present a somewhat different picture. All vowel contrasts were highly discriminable by both infant groups. Significant differences were observed in difficulty among the vowel contrasts. Significant differences were not, however, observed between the infant language experience groups. Contrasts in place of articulation in final nasals proved much more difficult to discriminate that the vowel contrasts. In fact, only the English-learning infants provided evidence of discrimination of one of these contrasts [æ̃m] - [æ̃ŋ]. No significant differences were found between infant groups on the nasal contrasts.

We were surprised by the relatively poor performance of the infants on the nasal place contrasts. We reasoned that they might have done badly because of over-exposure to our laboratory. All the children were subjects in a longitudinal study, requiring them to visit the lab often, and to be tested in the VRISD paradigm frequently. In order to assess whether the longitudinal population had been negatively affected by continual testing, we brought in 16 additional infants of similar backgrounds. This new cross-sectional population was trained and presented with the very same nasal contrasts, but were not tested on the vowel contrasts. The cross-sectional infants had, on the average, 80 fewer test or training trials prior to testing on the nasal sounds than did the longitudinals. Contrary to our expectations the cross-sectional infants performed significantly worse on the nasal contrasts than had the longitudinals. In addition, when the combined ANOVA for longitudinals and cross-sectionals was examined, it revealed

a significant difference for English-learning infants across the two nasal contrasts. English-learning infants performed significantly better on the [ɑ̃m] - [ɑ̃ŋ] pair than on the [ɑ̃m] - [ɑ̃n] pair.

DISCUSSION AND CONCLUSIONS

Our research to date on cross-linguistic infant speech perception provides a set of tentative suggestions about the role of experience and several additional factors in speech sound discriminability. Interpretation of these results has been guided by an interactive-pragmatic model, a model that poses roles for a variety of influences in the speech discrimination process. Consistent with the model, linguistic experience is used to explain the relatively better performance by Spanish-learning infants on a synthetic Spanish voicing contrast and the Spanish tap-trill distinction. English-learning infants' performance on English final nasals [æ̃m] and [æ̃ŋ] is better in both Experiments II and III (though not significantly so) than Spanish infants' performance, also perhaps due to listening experience.

However, it is obvious that additional influences need to be considered to explain the obtained pattern of results. The Spanish babies did significantly better than the English on the Czech contrast. Why? The model suggests at least two possibilities which could be empirically investigated. One is that the Czech contrast is somehow more like Spanish than English--that something about the Czech contrast is phonetically analogous to some Spanish contrast or set of contrasts and that experience of the Spanish babies (who hear an inevitable small proportion of English from TV and on-the-street conversations) may produce a generally more sensitive capacity to handle novel contrasts. If the latter opinion is correct, then Spanish babies' performance on several English contrasts (performance at least equal to that of the English babies on synthetic [pa] - [pha], natural [asá] - [azá], and multiple token natural [but] - [bʊt], [bIt] - [bit] and [æ̃m] - [æ̃n]) might also be due to their having had the relatively rich phonetic experience of a partially bilingual environment.

At the same time, relatively high level performance by both infant groups on several of the contrasts could be attributed to a pragmatic factor we have called "pschoacoustic saliency". Some contrasts seem to be easy, not only for linguistically experienced listeners but even for non-human primates and chinchillas (see Kuhl & Miller, 1975; Morse, et al, 1975). Prevocalic voice onset time contrasts for example, appear to be relatively easy psychoacoustically, yielding high performance in all groups.

The results on steady state vowels in Experiment II show high performance for both groups if we consider the fact that the stimuli employed were presented as multiple tokens. Since the multiple token task is expected to be more difficult than single token tasks, we conclude that high performance on vowels in Experiment II may indicate that vowel contrasts are inherently especially salient. Alternatively, it might be thought that vowels are heard with very high frequency and that the effect of such experience is to make steady state formant contrasts easy.

Place contrasts in the final nasals (which were also presented as multiple tokens but which use dynamic rather than steady state formant cues) were discriminated more poorly than vowel contrasts in Experiment II. Experiment III confirmed that the final nasal contrasts were quite difficult. A previous study has provided evidence that final place contrasts are relatively difficult for infants (Williams, 1978). It might also be noted that Shvachkin's (1973) work on young child speech perception yielded indications of special difficulties with VC syllables.

The reason for easier discrimination of [æ̃m] - [æ̃ŋ] as opposed to [æ̃m] - [æ̃n] in Experiments II and III could be experiential. The -ing morpheme is very common in English, and phrases like "I'm Verbing" offer a frequent context of

contrast for the final nasals [m] and [ŋ]. However, whether the frequency of occurence of [m] - [ŋ] is greater than that of [m] - [n] is not certain and will need to be addressed empirically.

The fact that babies in the longitudinal sample in Experiment II were significantly better in their performance than the less task-experienced cross-sectional babies offers an important methodological note. Experience with the VRISD paradigm appears to produce fairly rapid effects on an infant's performance. Whether this effect is merely to stabilize infant motoric activities in the experimental setting, or to literally focus their attention on the notion of phonetic contrast in general is not clear. Fither way we are left wondering if the paradigm might not be used fruitfully as a training technique for speech perception skills. Furthermore, the fact that longitudinal infants discriminated the nasal contrasts better thant the cross sectionals suggests that the VRISD paradigm can be used effectively as a research tool even in relatively extensive studies.

The explanatory possibilities we can suggest at this time in considering available data on cross-linguistic comparisons of infant speech perception are only a beginning. While it seems obvious that factors like phonetic analogy with familiar contrasts, frequency of occurrence of contrasts in speech, psycho-acoustic saliency and innate auditory structure must be involved in discriminability of sounds, we have only begun to scratch the surface of the patterns the research has so far revealed. The interactive-pragmatic model we endorse is not capable of making detailed predictions about discriminability at present. Our approach is to use the model to help guide experimental design and retrospective interpretation. Eventually, as empirical results provide a basis for a more elaborate model, a theoretical formulation with predictive qualities will be developed. But without raw facts of what infants do discriminate and how well they do it, it seems futile to try elaborating the model. As of now, we feel secure

in one conclusion: even during the first year of like, effects of listening experience on discrimination of speech contrasts are discernible. That some such effects may be influenced in a complex fashion by "amount of experience" (frequency of occurrence) and by "relevancy of experience" (analogy of experienced contrasts) seems likely. We look forward to a time when the clarification of these influences will make it possible to help explain not only the facts of infant speech perception but also the development of speech reception skills of young children learning to use speech contrasts meaningfully.

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